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International Telecommunication Union
Development Sector

Economic impact of COVID-19 on digital infrastructure

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Report of an Economic Experts Roundtable organized by ITU

Acknowledgements

The following report was prepared by Dr Raul Katz, Director of Business Strategy Research (Columbia Institute for Tele-Information) based on the input from participants in the ITU Economic Experts Roundtable[1], organized by the International Telecommunication Union (ITU) on 26 June 2020, and from research carried out since the start of the COVID-19 pandemic.

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[1] ITU Economic Experts Roundtable on COVID-19 and the Digital Economy (https://www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2020/EconomicRoundTable/home.aspx)

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Foreword

Around the world, COVID-19 has upended lives and economies. Global analysts predict that the world may be facing its deepest recession since the end of World War II.

At the same time, the pandemic has highlighted the crucial role of digital connectivity in keeping our societies functioning, as 'online everything' quickly became our new way of life.

Despite the surge in digital demand, however, important parts of the digital economy may not have escaped the economic fall-out from the crisis. If the financial difficulties faced by some market players constrain much-needed investment in digital infrastructure, the societal and economic consequences could be long, and far-reaching.

As COVID-19 hit, ITU's primary focus was on urgent actions to keep digital networks up and running, while galvanizing global action to extend digital connectivity to as many as possible. To that effect, we launched the ITU Global Network Resiliency Platform (REG4COVID), and worked through the Broadband Commission for Sustainable Development with partners, including the World Bank, the World Economic Forum and the GSMA, to set out a global digital agenda for immediate actions.

As we look ahead towards global recovery, it will be important for governments, digital policy makers and regulators, and the tech sector to ensure that further actions are based on solid evidence.

In this report, leading digital economy experts have put their collective heads together in an attempt to get a clearer look at the economic impact of COVID-19 on the world's digital infrastructure – not just a rear-view mirror look, but a far-sighted view from the driver's seat, too. Let me extend a special thank-you to ITU's long-standing collaborator, Dr Raul Katz of the Columbia Institute for Tele-Information, for so capably drawing all this knowledge together.

It is my hope that this report proves useful to a wide range of stakeholders from across the digital ecosystem in helping strengthen and extend our digital resources, and fully leverage the crucial role played by digital infrastructure and services in coping with one of humanity's greatest global challenges.

Doreen Bogdan-Martin
Director, ITU Telecommunication Development Bureau

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Executive summary

The views of the participants of the economic experts roundtable on the impact of COVID-19 on digital infrastructure can be synthesized as follows:

- While overall telecommunication networks have exhibited consistent resilience in the face of the changes in traffic,[1] accessible ultra-broadband technologies such as fibre-to-the-home (FTTH) appear to be better prepared to respond to spikes in broadband traffic. Countries with the largest deployments of accessible ultra-broadband have exhibited less slowdown in latency and download speed.[2]
- Wi-Fi capacity has been stressed by an 80 per cent increase in PC uploads to cloud computing platforms with additional peaks from video conference calls,[3] requiring additional spectrum to be assigned for unlicensed use.
- As is the case with the whole economy, the pandemic has had an almost immediate impact on the financial performance of digital infrastructure companies. The annual negative revenue impact on telecommunication operators could be up to 10 per cent, with some services requiring 18 to 24 months to return to pre-COVID-19 levels.[4] While media companies have been more significantly affected by the decline in advertising revenues as a result of the ensuing economic recession, Internet platforms have fared better in the economic downturn, which was implicitly reflected in different market capitalizations.
- The increase in traffic has resulted in an acceleration of capital expenditure (CAPEX) related to the expansion of capacity (i.e. operations and maintenance CAPEX). On the other hand, spending not related to an increase in capacity (i.e. network modernization) is being postponed, especially among emerging countries. While the top five operators in the Africa region spent USD 5.5 to 6 billion in 2019, it was expected that this would drop to USD 4.5 to 5 billion in 2020. Most experts agreed that, in the light of financial pressure, new infrastructure models (e.g. passive, rural and RAN sharing) would become more prevalent to reduce cash outlays.
- Future sources of funding to fill the gap could emerge from some governments (if capable of fostering counter-cyclical measures) or development finance institutions. As an example, the International Finance Corporation (IFC) is deploying a USD 2 billion line of credit and seeking investment opportunities.
- Current conditions of the digital economy sector could lead to industry consolidation, particularly among low-cost telecommunication operators in the developing world[5], and the public cloud, satellite TV, and in-flight Internet access sectors.

The roundtable participants fully agreed on the capacity of digital infrastructure to enhance social and economic resilience in the face of the pandemic:

- While research on the contribution of digitization to mitigate the impact of pandemics is limited, emerging evidence is compelling about its positive effects. In the medium term (e.g. 2021), countries with top connectivity infrastructure could mitigate up to half of the negative economic impact.

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1 Sinibaldi, G. (2020). *COVID-19 is revolutionizing digital communications and testing providers' reliability and ability to innovate*. Analysys Mason, April.

2 Katz, R., Jung, J. and Callorda, F. (2020). *Can digitization mitigate COVID-19 damages? Evidence from developing countries*. SSRN.

3 Gil, T. et al. (2020). *The new normal: holiday level Wi-Fi upload.*

4 Delta Partners. (2020) *Outlook for telecom operators post COVID-19. Global telecom executives survey*. May, p. 8.

5 Low-cost telecommunications operators, also called "budget operators, have highly streamlined operating models that enable them develop offers targeted for low income population.

- That being said, some factors exist that limit the capacity of digitization to improve social and economic resilience.
- First and foremost, the digital divide has been highlighted as a critical barrier to the mitigation value of digitization. In particular, population unserved or partially served by broadband cannot benefit from distance learning for children, telecommuting, access to e-commerce and healthcare information. Population coverage of 4G networks in sub-Sahara Africa is 53 per cent and 78 per cent in Eastern Europe.[6] Beyond coverage, demand-side barriers (such as limited affordability and digital illiteracy) have become a critical barrier. Internet adoption in Latin America and the Caribbean is 70 per cent, 38 per cent in sub-Sahara Africa, and even advanced economies still have some gaps (91 per cent in North America, and 86 per cent in Western Europe).[7]
- While large enterprises benefit from access to well-established digital solutions in place (collaboration tools, employee devices, cloud, VPN, etc.) and connectivity, this is not the case for a large portion of small and medium-sized enterprises (SMEs), particularly in developing countries. The use of the Internet for business purposes in sub-Sahara Africa is as low as 7 per cent on average.[8]
- Furthermore, the benefits of digital infrastructure for dealing with the pandemic is limited to those industries that are well on their way to digital transformation, such as logistics.
- While supply chains have been fairly resilient with the help of digital technologies, the situation in developing countries is less positive.
- While governments have been very active in deploying policies aimed at improving the resilience of digital infrastructure (over 250 different regulatory responses have been identified around the world),[9] the current shock is calling into question some of the basic policy tenets of digitization development, most importantly in terms of how the digital divide needs to be tackled.

In order to increase the power of digitization to mitigate the pandemic disruption, the digital infrastructure sector needs to re-examine some of the digital sector basic fundamental premises that were held before COVID-19:

- It is crucial for governments to learn from these hard lessons and take concrete, actionable measures in the telecommunication sector to enable the private operators to provide universal access to quality digital infrastructure networks for all and support the development of a digital economy.
- Governments should take a much broader, holistic view of investment in high-speed broadband networks, considering the economic, social and environment/climate benefits and costs of investment.
- Regulatory frameworks may need to be adjusted to stimulate investment whilst maintaining a "sensible" level of competition, shifting from a "purist" to a "pragmatic" viewpoint on State aid regulations.
- It is paramount for governments in emerging markets to keep making progress on digital infrastructure regulation, particularly pertaining to shared infrastructure.
- The roundtable experts argued that COVID-19 could be a window of opportunity to drive digital transformation in sectors which have not promoted it in previous decades. Similar to the effect of SARS in China in 2003 which triggered the tremendous growth in e-commerce, new production modes would emerge. As a result, COVID-19 could become a catalyst for the adoption of digitization in sectors where it had not occurred before, especially in more business-oriented applications.

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6 GSMA Intelligence.
7 2020 extrapolation from International Telecommunication Union 2019 data.
8 Research ICT Africa (2020). *A demand side view of informality and financial inclusion* (February 27).
9 OMDIA (2020). *Telecoms regulation COVID-19 Tracker*.

Introduction

The COVID-19 outbreak has led to revised growth forecasts for the global economy. Every aspect of our lives has been affected by the outbreak. Its impact on economic activity is extremely broad: from dramatically diminished consumer discretionary spending to a freeze on business activities including capital budgets, hiring, and a reduction in everything but essential operational expenses. Even so, it is clear that under the current conditions some businesses may become more critical to our lives and could face an increase in demand, such as in the case of the information and communication technology (ICT) industry.

During the global pandemic, digital technologies have become a critical enabler of connectivity facilitating the continuity of our regular lives and connecting people more than ever before. As cities and countries have been asking the population to stay at home, more people have turned to their computers and smartphones as a lifeline and tools to substitute their in-person activities online. Some of the habits may continue in the "new normal" or at least until a long-term solution to the current challenges, such as a vaccine, is found. Hence, the need to access a reliable digital infrastructure has become increasingly important, and certain aspects of ICTs are critical in a period of isolation, such as increased ICT opportunities from telework, telemedicine, food delivery and logistics, online and contactless payments, remote learning and entertainment.

In line with this, the International Telecommunication Union (ITU) gathered leading ICT economic experts to exchange views on the latest research and analysis on: (a) the economic impact of COVID-19 on digital infrastructure; and (b) the contribution of the said infrastructure to building social and economic resilience in the context of the pandemic. In preparation for the roundtable, a survey was sent to the panellists, requesting them to share any relevant research they had carried out on the two topics. The roundtable was held on 24 June 2020[1].

The following provides a summary of the responses to the survey, along with their comments over the course of the roundtable and references to the research conducted to date. The findings and conclusions provide a concise and actionable report of potential initiatives within the digital economy space to increase social and economic resilience.

[1] ECONOMIC EXPERTS ROUNDTABLE "COVID-19 and the Digital Economy" was held on 24 June 2020. More information including the recording of the session is available at https://www.itu.int/en/ITU-D/Regulatory-Market/Pages/Events2020/EconomicRoundTable/home.aspx

1. The impact of COVID-19 on digital infrastructure

A primary motivation for assessing this issue was to understand how telecommunication networks have performed in the face of the pandemic-triggered lockdown. Along those lines, even if networks performed appropriately, could any potential points of failure be considered in future planning? Another concern that triggered the need to address the issue of impact on digital infrastructure was to understand whether the financial disruption caused by the pandemic was going to have an impact on the rate of deployment of advanced telecommunication technologies, such as 5G and optical fibre. Would that impact countries differently? OECD countries have reached a 5G coverage of 34 per cent[1] while fibre-optic household penetration is at 34.61 per cent.[2] Would the potential curtailment of capital affect this development vector in advanced economies? On the other hand, 5G population coverage in emerging economies is embryonic (3.2 per cent in Latin America, 15 per cent in Asia-Pacific region, 16.4 per cent in Eastern Europe, 15.4 per cent in the Arab States region, and still at 0 per cent in sub-Sahara Africa).[3] Similarly, in the case of optical fibre, household penetration in the developing world is relatively low (12.3 per cent in Latin America, and 0.6 per cent in sub-Sahara Africa).[4] In this context, would a slowdown in spending in the developing world accentuate the gap between advanced and emerging countries? And finally, would the impact on capital spending, particularly in developing economies, weaken the objective of achieving universal broadband coverage?

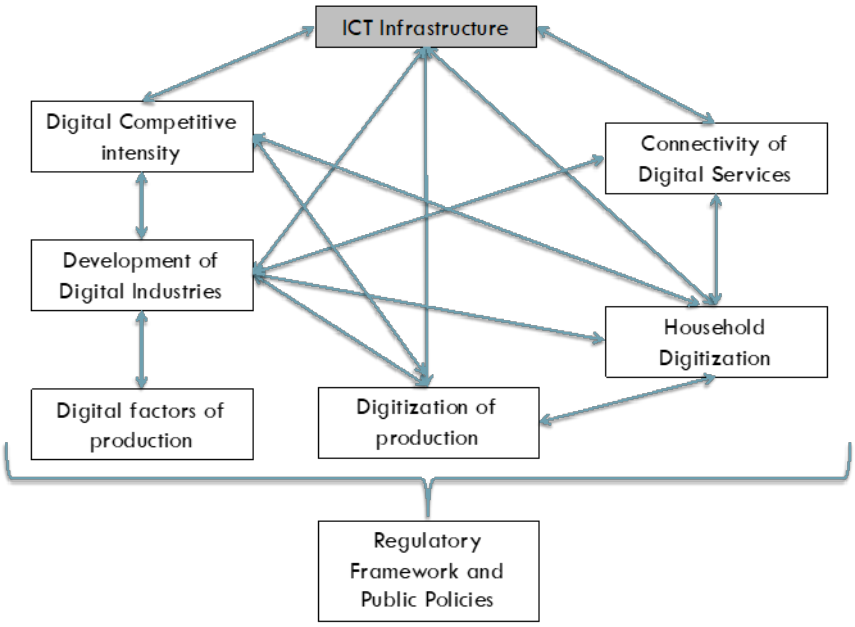
1.1. Impact on telecommunication networks

Digital infrastructure represents a critical component of a country's economy, facilitating the flow of goods, enabling exports, and ensuring the delivery of public services to the population. Telecommunication networks, the backbone of digital infrastructure, are structured around three components: a) international networks, which ensure a nation's connectivity with the rest of the world, b) domestic transmission backbones, which support the transport of signals between urban centres, and c) access networks, deployed to reach the "last mile" of telecommunication users. From a technology standpoint, international networks are supported by submarine cables, fibre-optic or microwave terrestrial networks, and satellite communications. Domestic transmission backbones are based on either fibre-optic, microwave, or satellite links. Access networks can rely on legacy technology (such as copper wires), or fibre-optic, cable modem links and wireless networks. Each technology has been evolving over time, based on successive waves of innovation, such as wireless "generations" (2G, 3G, 4G, and 5G).

Digital infrastructure is at the centre of an ecosystem called the digital economy. This ecosystem is composed of eight interconnected components (see Figure 1).

1 Source: Prorated GSMA intelligence 5G coverage for 2020.
2 Source: Prorated IDATE and other public sources of FTTx penetration for 2019.
3 Source: Prorated GSMA intelligence 5G coverage for 2020.
4 Source: Prorated IDATE and other public sources of FTTx penetration for 2019.

Figure 1: Structure of the digital economy



Source: ITU, The Economic Contribution of Broadband, Digitization and ICT Regulation[5]

The infrastructure of digital services provides individuals, businesses and governments with access to digital content and services. It also supplies interconnectivity to players within the digital value chain (e.g. developers of digital content, Internet platforms, etc.) so that they can deliver a value proposition to users. If the infrastructure does not perform in response to social and economic demands, it has a negative impact on the whole digital ecosystem. This is the reason why it is critical to evaluate how telecommunication networks have performed in response to recent massive disruptions.

1.1.1. Impact of traffic changes on network performance

The gradual deployment of prophylactic measures taken to deal with COVID-19, such as the closure of workplaces and home quarantine, has led to a spike in telecommunication network usage. Overall, Internet traffic has increased by approximately 30 per cent. The transition to telecommuting has brought about a shift from enterprise to residential access. Traffic no longer comes primarily from central business districts, shifting instead to residential areas. Similarly, in response to the lockdown, a portion of data traffic has shifted from mobile to fixed/Wi-Fi networks. Daily traffic patterns have also changed. Contrary to the period prior to COVID-19, Internet traffic has started to surge in the morning at levels close to the evening peak, partly as a result of telecommuting, but also driven by sustained streaming usage.[6] Finally, mobile voice traffic has grown strongly, driven by an increase in both the number of calls and their duration.

Looking forward, some experts consider that the overall increase in traffic will become a fixture of the future. As one roundtable expert put it, “the likelihood is that once traffic reaches new levels, it won’t go back, as binge TV watching, and home-based working become part of the ‘new normal’”. Table 1 provides some examples of the increase in traffic compiled from telecommunication operators and OTT platforms.

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[5] The ITU series on "The economic contribution of broadband, digitization and ICT regulation" examines this revolution from a data and evidence-based perspective. It quantifies the positive impact of broadband, digital transformation, and the interplay of ICT regulation on national economies by applying econometric modelling techniques. Available at : https://www.itu.int/en/ITU-D/Regulatory-Market/Pages/Economic-Contribution.aspx

[6] Reynolds, M. (2020). *State of the Internet amid coronavirus pandemic*, S&P Global Ratings June 16, p. 2.

Table 1: Internet usage increase triggered by COVID-19 (examples)

Area	Service provider	Area of usage percent increase	Source
	AT&T (US)	Core network traffic (22%)	AT&T
Telecommunication traffic	British Telecom (UK)	Fixed network traffic (60% on weekdays)	British Telecom
	Telecom Italia (Italy)	Internet traffic (70%)	Telecom Italia
	Vodafone	Mobile data traffic in Italy and Spain (30%)	Vodafone
		Facebook Messenger (50%)	Facebook
Over The Top (OTT)	Facebook	WhatsApp (Overall: 50%; Spain: 76%)	WhatsApp
		Video calling (100%)	Facebook
	Netflix	Subscriber base (9.6% or 16 million)	Netflix
	E-commerce (Mexico)	Number of Users (8%)	Competitive Intelligence
	Zoom	Daily usage (300%)	JP Morgan
Video conferencing	Cisco Webex	Subscribers (33%)	Cisco
	Teams (Italy)	Monthly users (775%)	Microsoft

Source: Analysys Mason (2020).

The above reported increases in usage have led, consequently, to a temporary erosion of certain network quality indices. According to Ookla/Speedtest, the average Internet speed and latency indices of several countries have changed dramatically since the beginning of February 2020.

On the other hand, the lockdown measures triggered by the spread of COVID-19 did not affect all countries and regions in a uniform fashion or at the same time. To start with, the worldwide rate of contagion had an impact on the time at which national lockdowns were put in place. For example, the lockdown in China was implemented on 2 February 2020, while the quarantine in Europe and the United States of America started in mid-March 2020. In addition, countries did not follow a uniform lockdown pattern. Some countries adopted strict quarantine, affecting schools, workplaces, retailers and the like in a uniform fashion throughout their territories. Other countries imposed lockdowns in selected regions and/or states. In some countries where quarantine was imposed nationwide, the implementation of measures was gradual. Finally, there were some cases where lockdowns were not enforced (e.g. Kenya, Sweden). Different lockdown models have had varying impacts on the performance of networks: uniform national lockdowns caused a decline in broadband speeds and an increase in latency, while gradual measures have had less noticeable effect. Figure 2 presents some selected examples across developing countries.

Figure 2: Internet speed in selected countries (February-June 2020)

Source: Katz, R., Jung, J. and Callorda, F. (2020). Can digitization mitigate COVID-19 damages? Evidence from developing countries. SSRN. from Ookla/Speedtest.

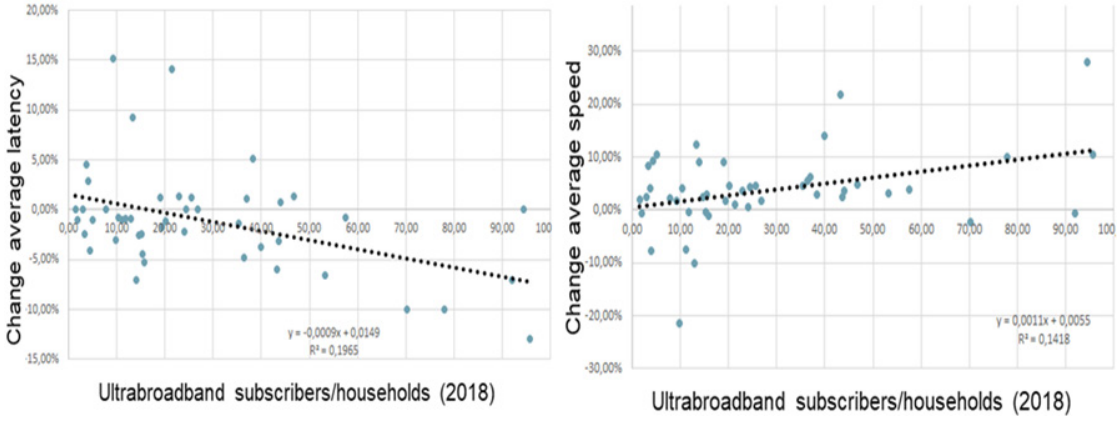
The data presented in Figure 2 show decreases in broadband speed during March and April 2020, likely reflecting peaks in Internet access combined with changes in behaviour and traffic flow as, for instance, more people began to work from home. This is particularly evident in the case of fixed broadband in all reported cases, although with more intensity in Chile, Ecuador, Morocco, South Africa, and Turkey. In the case of mobile broadband, significant variations were identified in Morocco, South Africa, and Turkey.

1.1.2. Network resilience and potential "pain" points

As has been reported by many analysts, most telecommunication operators have been able to cope with the surge in demand with limited disruption. The surge has not affected the overall Internet, particularly in advanced economies, where there are different possible routing paths and networks to rely upon. Since the telecommunication, cable and fibre-only companies that run the Internet backbone keep 50 per cent of available capacity all the time, this means that, in the aggregate, capacity was able to handle increased traffic. Furthermore, while caught off guard in the initial stage of the lockdown, service providers put in place a number of fixes and practices to accommodate the surge. For example, consumers were encouraged to enable Wi-Fi calling on their devices to reduce cellular traffic. Some operators opened up their public Wi-Fi hot spots to all of their customers. Others offered free calls for elderly users, fixed voice bill caps, as well as prioritized calling to emergency numbers.[7]

In addition, some digital infrastructure was better able to handle the increase in traffic. Countries that had a higher level of ultra-fast broadband infrastructure deployed (for example, those with higher penetration of optical fibre) have appeared to handle the increase in traffic better. Correlations shown in Figure 3 provide evidence that the higher the ultra-broadband penetration in a given country, the less the increase in latency and the decline in download speed from the levels before the pandemic.

Figure 3: Impact of COVID-19 induced traffic increase on latency and speed (changes from November 2019 – January 2020 and March 2020)



Source: Katz, R., Jung, J. and Callorda, F. (2020). Can digitization mitigate COVID-19 damages? Evidence from developing countries. SSRN.

On the other hand, traffic surges and the changes in patterns have highlighted potential network pain points. One of the most immediate effects of the pandemic has been the shutting of offices, schools, and factories to prevent contagion, which in turn has led to a dramatic increase in telecommuting, and consequently, in data traffic from households. One of the network pain points is the broadband uplink. Enterprise traffic is less asymmetric than consumer traffic. Useable frequencies in coaxial cables are a scarce resource (particularly under legacy standards) and are allocated according to typical current traffic rather than to increased need.[8]

This natural increase in the number of devices using video conferencing and cloud computing platforms now connected at home has created a bottleneck in Wi-Fi routers that operate on non-licensed spectrum. Based on traffic measurement statistics, this technology has experienced peaks as a result of increased telecommuting (see Figure 4).

[7] Sinibaldi, G. (2020). *COVID-19 is revolutionizing digital communications and testing providers' reliability and ability to innovate*. Analysys Mason, April.

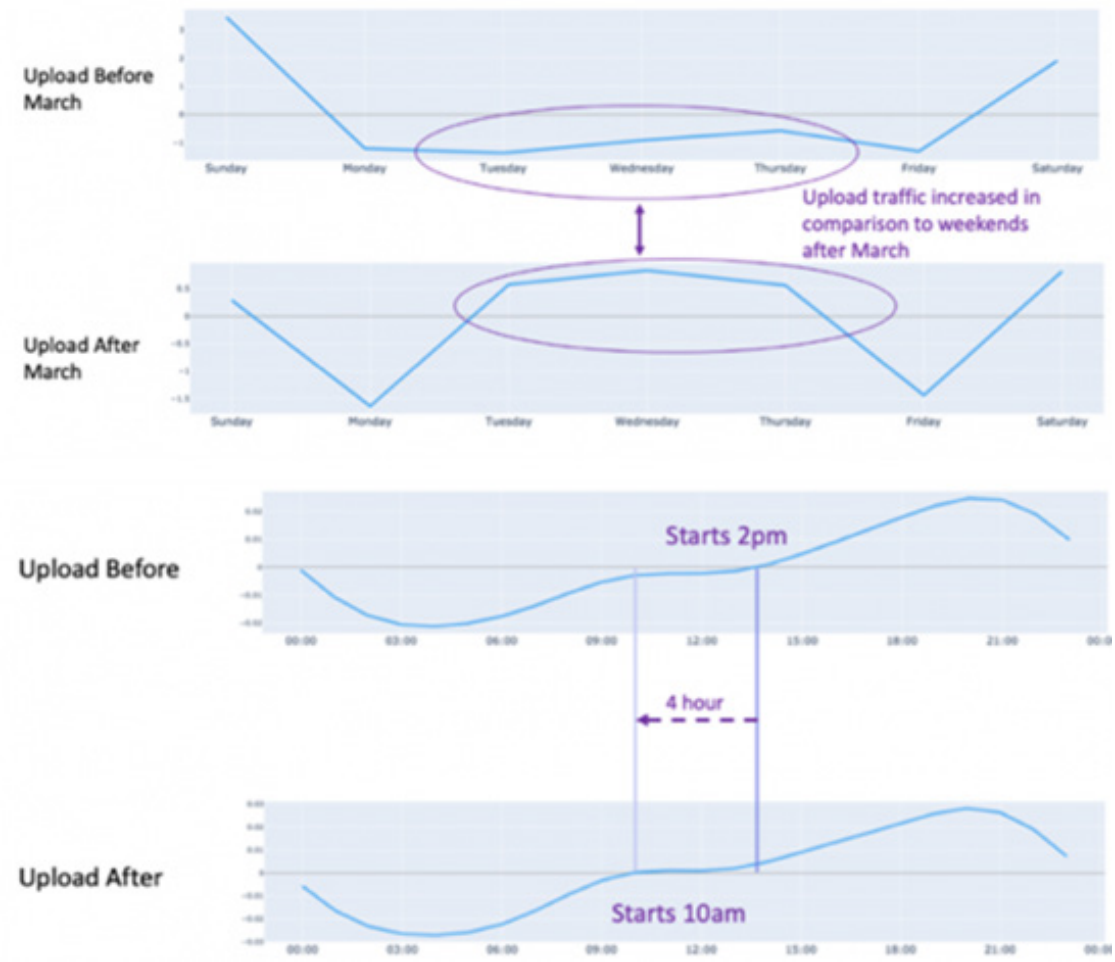
[8] Wood, R. (2020*). COVID-19: operators should be concerned about the robustness of networks rather than capacity*. Analysys Mason (March), p. 2.

Figure 4: Global Wi-Fi traffic growth (December 2019 – April 2020)

Source: Gil, T. et al. (2020). The new normal: holiday level Wi-Fi upload.

As depicted in Figure 4, data collected from 125 million Wi-Fi routers around the world have shown an 80 per cent increase in PC uploads to cloud computing platforms with additional peaks from videoconference calls since the end of March. In addition, a change in usage patterns has caused an increase in router traffic. The traditional weekday-weekend and time-of-day usage patterns have shifted. With videoconferencing happening from home during the week, what used to be weekend traffic profiles are now occurring throughout the week, in addition to a four-hour earlier start to peak upload traffic patterns during the day (see Figure 5).

Figure 5: Wi-Fi upstreaming behaviour



Source: Gil, T. (2020). The new normal: holiday level Wi-Fi upload.

This increase has contributed to the saturation of unlicensed spectrum bands (generally 2.4 GHz and 5 GHz). According to Assia, a Wi-Fi system company,[9] interference on the 2.4 GHz band was already high before the March lockdown but has since jumped by another 10 per cent. Even more remarkable is that interference on the 5 GHz band is up by 30 per cent since the start of the lockdown.

1.1.3. The future of networks

There is universal consensus that, despite the initial impact, fixed and mobile broadband networks and the Internet backbone have shown a high level of resilience in the face of the COVID-19 disruption. Looking forward, however, it is critical to examine some potential points of failure to be addressed in the future. As shown below, when examining consumer demand, some of the current traffic patterns will become permanent as telecommuting persists. Under these conditions, this most probably means that the home broadband connectivity and remote computing systems will remain ever more critical in terms of speed, latency, security, reliability and cost.[10] Researchers expect demand for quality home broadband to be more important than ever. One possible effect could be a deceleration in the churn on traditional wireline voice services for those looking for a more reliable work-from-home solution if they have wireless coverage or broadband issues.[11]

From an industrial standpoint, wireline carriers with substantial fibre-optic deployment will benefit, while service providers with a significant copper/DSL base will lose subscribers. With a change in traffic patterns, a reduction in traffic asymmetry will push for greater reliance on upstream capacity. This will also prompt some carriers to review their service levels and offers.

From a technology perspective, current spectrum assignment decisions to increase bands assigned to Wi-Fi (April voting by the Federal Communications Commission (FCC) in the United States, ongoing consideration in Brazil, decision in the Republic of Korea) should have a significant effect in alleviating the household router bottleneck.

1.2. The impact on the digital economy

As expected, the economic recession has and will continue to exert an impact on the performance of industries comprising the digital economy. For the purposes of this analysis, the digital economy is defined as composed of the firms providing digital goods and services, either for final or intermediate consumption.[12] The questions raised in the roundtable focused on issues of future financial performance and the consequent effect on capital spending, shedding some light on the differences between advanced and developing economies.

1.2.1. Financial performance

As is the case with the whole economy, the pandemic had an almost immediate impact on the financial performance of digital infrastructure companies. The intensity of the impact was more acute for telecommunication service providers than Internet platforms. Revenues of telecommunication operators in the first quarter of 2020 declined an average of 0.9 per cent for an average lockdown period of approximately 15 days. Consistent with the different lockdown patterns reviewed above, revenue declines varied by region, with the most important impact taking place in Europe. Revenue decline has been driven by a logical reduction in roaming due to travel restrictions plus a decline in equipment sales as a result of store closures and the postponement of in-premise customer installations. Revenue decline has been partially compensated by fixed line and B2B revenue driven

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9 Gil, T. (2020). *The new normal: holiday level Wi-Fi upload.*

10 Flannery, S. et al. (2020). *Global Technology: Can WFH Plays WFH (Work from Here*), Morgan Stanley. June 9.

11 Flannery, S. (2020). *Mapping the new normal for telecom services and communications infrastructure,* Morgan Stanley. June 11, p. 3.

12 See Ahmad, Nadim, and Jennifer Ribarsky, 2017, *Issue Paper on a Proposed Framework for a Satellite Account for Measuring the Digital Economy*, Presented at the 5th IMF Statistical Forum.

by products and services required to support telecommuting workers.[13] It should be pointed out, however, that the above revenue forecasts were not uniform across all markets and all operators within a single market. For example, as reported by a roundtable expert, dominant operators in several African markets appeared to be performing fairly well under the current conditions.

Beyond telecommunications, the digital media sector was immediately affected by COVID-19, especially in out-of-the-home content consumption due to social distancing and mandated closures of live events and cinemas. As expected, television viewing has skyrocketed. Even as content preference changed, the average consumer in North America watched seven hours of television daily, up one hour from the pre-pandemic period.[14] Furthermore, despite economic concerns, consumers have been adding more streaming subscription services, beyond the usual Netflix.[15] PayTV operators have been offering free and low-cost Internet packages to qualifying households. A recent study by CTAM found that 7 per cent of households in the United States had signed up for broadband in the two months since the crisis began, and 17 per cent of those did not have Internet at home at all before.[16]

The forward-looking view of the financial impact on digital economy companies is more uncertain. Of the 29 major telecommunication carriers monitored by Delta Partners, 14 have suspended guidance. Underlining the uncertainty, there has been no consensus among economic experts on the future financial impact. One roundtable expert estimated that the ongoing extension of lockdown in the second quarter of 2020 will yield a revenue decline between 2 and 4 per cent.[17] Another researcher forecasted a decline in the range of 4 per cent (or USD 51 billion) for the whole year compared to 2019. Telecommunication executives believe the annual revenue impact could be as much as 10 per cent, with some services (e.g. international roaming revenue) requiring 18 to 24 months to return to pre-COVID-19 levels.[18] Some of the revenue decline would be compensated by increased broadband usage by enterprises. With social distance persisting, companies would continue to migrate to low-touch models of interaction.

As reported by one expert, the decline in revenues, combined with an increase in bad debt and increased marketing costs has resulted in a negative EBITDA impact of-2.1 per cent in the first quarter of 2020. Again, the larger decline took place in Europe (BT:-4.7 per cent, Telia:-1.3 per cent, Telefonica:-0.8 per cent) and the United States (AT&T:-2.9 per cent). As stated by one roundtable expert, increasingly there was an impact on the working capital requirements as all operators deferred payments, shifted to a cash conservation mode including a CAPEX freeze and sought to refinance maturities of debt becoming due in the next 12 months. Finally, another roundtable expert estimated that a dramatic slowdown in sector performance would materialize in 2021, especially in the developing world, since by then the larger economic crisis would have percolated through telecommunications.

Media companies were also highly affected by the decline in advertising revenues as a result of the ensuing economic recession. As in the case of telecommunications, these players have taken action to preserve and increase cash balances, through either issuance of debt or drawing down of revolving credit facilities, as well as implementing cost-cutting measures.[19]

Finally, roundtable experts pointed out that, because of lower dependence on infrastructure spending, Internet platforms (or "Over The Top" providers) would generally be faring better than network operators during the economic downturn, a trend which was implicitly reflected in different market capitalizations.

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13 Delta Partners (2020). *COVID-19's impact on telecom operators.* June.
14 Williams, J. (2020). *TV, streaming models may be permanently changed by COVID-19*, S&P Global Ratings June 9, p. 2.
15 Reynolds, M. (2020). *State of the Internet amid coronavirus pandemic*, S&P Global Ratings June 16, p. 2.
16 Williams, J. (2020). *TV, streaming models may be permanently changed by COVID-19*, S&P Global Ratings June 9, p. 2.
17 Delta Partners. (2020) *COVID-19's impact on telecom operators. Assessment of Q1 results announcements from global listed telecom operators*. June, p. 13.
18 Delta Partners. (2020) *Outlook for telecom operators post COVID-19. Global telecom executives survey*. May, p. 8.
19 Sarma, N. and Lynch, N. (2020). *Pandemic and recession deal blows to credit metrics of US Media and Entertainment Industry*, S&P Global Ratings. June 19, p. 5.

1.2.2. Capital spending

The capital investment of a telecommunication service provider is composed of (i) an amount targeted for network modernization (such as 5G or FTTH deployment) and (ii) other non-discretionary expenditures (i.e. investments that cannot be eliminated since they have an impact on the ongoing quality of service). Non-discretionary capital expenditures include the replacement of legacy network equipment (such as a 3G base station) or the so-called "surgical" deployment of infrastructure aimed at addressing sudden non-forecast peaks in traffic. These non-discretionary components are generally labelled "maintenance CAPEX". When facing a big technological modernization wave such as the deployment of 5G, telecommunication carriers begin gradually reducing their maintenance CAPEX and transferring investment capital to the deployment of new networks. In the case where modernization takes place within high-capital efficient technology areas, the transition can be achieved within the ongoing CAPEX load, avoiding any increase. On the other hand, if the transition requires a higher rate of innovation, CAPEX will increase in relation to the sum assigned in previous years. As expected, innovation investment will yield efficiencies on the operating side.

The increase in traffic reported in Graphic 1 has resulted in an acceleration of CAPEX related to the expansion of capacity (i.e. maintenance CAPEX). Consequently, spending not related to an increase in capacity (i.e. network modernization) was partially postponed, especially in Europe.

Table 2: CAPEX priorities as announced by selected carriers

During COVID	Future plans
• Telefonica: FTTx, capacity upgrades, network virtualization, improvement of customer experience	• BT: FTTP and 5G within five-year programme
• TIM: IT, 4G, transport network (95%) and FTTH (15%)	• ETISALAT: 5G, data centres and capacity upgrade
• Vodafone: capacity upgrade and Gbit/s network infrastructure	• MTN: resilience and capacity of networks
• Ooredoo: network upgrades and maintenance, IT transformation programme	• KPN: FTTH and mobile network modernization

Source: Delta Partners. COVID-19's impact on telecom operators. Assessment of Q1 results announcements from global listed telecom operators.

Underlining the financial uncertainty, the forward-looking view on capital spending as discussed in the economic experts roundtable was somewhat mixed. First and foremost, the long-term outlook in CAPEX was contingent upon the speed of recovery. Secondly, most experts agreed that, in the light of financial pressure, new infrastructure models (e.g. passive, rural and RAN sharing) would become more prevalent to reduce cash outlays.

In addition, roundtable experts held similar views regarding the future evolution of overall CAPEX. The most dramatic view forecasted that the revenue decrease would trigger cash conservation modes, including CAPEX freezes or some 5G reduction (driven in part by supply change delays, or launch postponement).[20] A second position estimated that a shift to investment in network capacity and resilience would occur, with a consequent delay in 5G deployment. A third position considered that investment in network modernization would be primarily focused on urban environments, postponing deployment of new technology in suburban and/or rural areas.

[20] The delays in 5G roll-out could also be the result of: disruption to network equipment vendors' global supply chains; reduced capacity for equipment manufacturing, delivery and commissioning; delays to 3GPP Release 16 Stage 2 and Release 17 standards that could impact 5G uptake for the next several years; and spectrum licensing put on hold or at least postponed in many countries until the crisis begins to recede.

Another dimension affecting the overall capacity of infrastructure players to invest concerns Internet platforms that have been relatively unaffected by the stock market and enjoy a continuing capacity to invest in deploying infrastructure, either in submarine cables (see Facebook and Google deployment) or last-mile networks in developing countries.

All experts agreed that future capital spending would vary by geographical area. On the question of investment in 5G, service providers in countries with relatively advanced 5G deployment (e.g. operators in advanced economies) would continue with their plans, while operators in nations with embryonic deployment (e.g. developing countries) would slow down 5G investment. For those carriers pursuing 5G roll-out, investment in network modernization would be primarily focused on urban environments, postponing deployment of new technology in suburban and/or rural areas. The low ARPUs in developing countries would force telecommunication operators to postpone capital spending in 5G. As an example, a roundtable expert mentioned that the top five operators in the Africa region spent USD 5.5 to 6 billion in 2019 while it was expected that this would drop to USD 4.5 to 5 billion for 2020. As mentioned by one expert: "The reduction of telecommunications capital spending as a result of the COVID-19 induced economic downturn will have a negative impact on the rate of network expansion, particularly in rural areas." In addition, some experts considered that "delayed deployment of 5G and extended high-speed and fibre networks in many countries means a longer period before businesses and consumers in these markets get access to higher speeds and advanced services. This could actually worsen the impact of the economic downturn".

On the positive side, an expert considered that some slowing of 5G deployments may not all be bad news for the broader ecosystem: "Any slowdown could allow operators more time to rectify issues that were not fully resolved in the rush to deploy commercial 5G services. This includes work on optimizing 5G NR performance, improving the fallback experience in dual-connectivity mode, and addressing device-related issues, such as the effects of overheating in smartphones".[21] Interestingly enough, COVID-19 might trigger a shift in where operators re-focus their use cases. For example, reduced interest in areas such as targeted coverage for large venues like sports and concerts could be replaced by a greater focus on the wider support for low-latency applications, such as the use of robotics in health care and edge computing.

1.2.3. Future sources of funding

A related question on the future trend in capital spending is whether other sources of funding would be available to fill potential gaps. Some experts pointed out the need for public counter-cyclical spending, arguing for the need to call for governments to take a more proactive role in providing funds to address the digital divide. Yet, while most roundtable participants agreed with the need to tackle unserved populations, some mentioned that since the telecommunication industry had been substantially less affected compared to other sectors (e.g. airlines, travel and lodging, etc.), public funds would not be expected to flow to the digital sector. Furthermore, while other experts agreed with the need for counter-cyclical interventions, they raised the question as to whether developing country governments would have the cash to fund the digital divide initiative. In particular, many highly indebted countries in the Africa region would not be able to fund infrastructure investments.

Beyond the public sector, many experts pointed to the role that could be played by development finance institutions (World Bank/International Finance Corporation (WB/IFC)), Inter-American Development Bank (IDB), Asian Infrastructure Investment Bank (AIIB)) as spending gap fillers. This is supported by recent moves from the IFC that has been deploying a USD 2 billion line of credit and seeking investment opportunities. From a somewhat complementary perspective, some experts argued that rather than providing public funds, governments could alleviate the shortfall by providing incentives that would allow the private sector (i.e. telecommunication carriers) to continue to invest, either in addressing the digital divide or deploying advanced technologies (5G and optical fibre). This could include alleviating the taxation burden or re-examining spectrum auction rules.

[21] OMDIA (2020). *COVID-19 Market impact: Service Provider Markets*, May.

Finally, there was uncertainty as to whether public capital markets and/or private equity could play a role in this circumstance.

1.2.4. Impact on industry structure

Given the potential impact of the recession on the telecommunication sector, some experts raised the issue of whether this could have an effect on industry structure. Some consensus emerged in terms of the potential for consolidation, although views diverged as to which players would be acquired as a result of financial difficulties. Recent bankruptcy filings (OneWeb, Intelsat, Frontier and Windstream) could pre-announce a wave of industry consolidation.

This view was not universally shared by roundtable experts. For example, while some new entrants may struggle in the short term for cash, their financial backers, which are increasingly infrastructure funds, would help them through it. Along those lines, some of those investors' traditional sectors (toll roads, airports, etc.) are less resilient to COVID-19-like shocks, so funders might redirect a greater share of their funds towards digital over the longer term, to mitigate similar future events. An additional counterpoint to the impending sector consolidation is the argument that network sharing agreements could alleviate the cash crunch and become a mitigant to acquisition threat.

One expert pointed to the industry exit by low-cost carriers in developing countries. These budget telecommunication operators originally entered the market with offers particularly targeted to low-income populations. Their business model could become stressed by the reduction in consumer spending. Another expert considered that new telecommunication entrants that were not adequately backed by strong investors would be acquired.

Beyond telecommunications, consolidation was also mentioned as a possibility in cloud services, satellite TV, and in-flight Internet access.[22]

The changes in industry structure were considered to be a risk to the ability of the sector to increase social and economic resilience. For example, industry concentration could result in a limit for the sector on deploying technology in lower income areas. Another risk could derive from the extreme concentration of public cloud service providers. As explained by one roundtable expert, the pandemic has accelerated the adoption of the public cloud, with services (outside China) dominated by Amazon Web Services, Microsoft Azure and Google Cloud. This could potentially lead to a situation where cloud providers become "too big to fail", and the need for government protection in case of a financial or technical failure. Furthermore, the replacement of on-premise computing with the public cloud means a shift from local/national companies to global multinational corporations (MNCs). This has consequences for how much local tax is collected, and where well-paid jobs are created. In this context, as stated by a roundtable expert, "contrary to what occurs in the case of telecommunication networks, the global public cloud providers are regulated in a relatively low 'light-touch' way".

2. Does digital infrastructure increase social and economic resilience?

The second topic addressed in the roundtable of economic experts focused on the contribution of digital infrastructure to social and economic resilience in the face of the pandemic. For analytical purposes, socio-economic resilience is defined as the ability of a society to overcome crucial challenges such as wars or pandemics and return to normalcy, thereby providing a path for future development. In the words of a roundtable expert, after medical treatment, the next most important and critical infrastructure during the COVID-19 pandemic was telecommunications. Two key issues prompted the need to address this topic: if digital infrastructure was a key contributor to social and economic

[22] Flannery, S., Park, L., Lam, L. Roper, A., and Barajas, D. (2020). *Mapping the new normal for telecom services & communications infrastructure*. Morgan Stanley (June 11), p. 6.

resilience, were developing economies less prepared than advanced nations to face the consequences of the pandemic? Furthermore, with a high rate of digital divide in developing countries, was the obligated reliance on ICT reinforcing social exclusion and inequality? In this context, the roundtable focused first on social resilience, highlighting the challenges of the digital divide. It also focused on economic resilience, summarizing the research evidence on the capability of digital infrastructure to support the production and distribution of goods and services. As background information, the following section highlights existing research on the contribution of digital infrastructure to building socio-economic resilience in the face of pandemics.

2.1. State of research regarding the contribution of digital infrastructure to resilience in the face of pandemics

Following the initial wave of the fear of contagion and the implementation of prophylactic measures, anecdotal evidence immediately emerged, suggesting that digital technologies could contribute to counteracting the isolation implied by social distancing measures, increasing the awareness of virus prevention measures, and allowing economic systems to continue to operate, at least partially. The exponential increase in Internet traffic, the reliance on telecommuting, and the need to maintain high-performing supply and distribution chains support this claim. In this context, the existence of research testing the link between highly developed digital ecosystems and country preparedness in the face of pandemics is still limited. When asked in the survey, experts generally referred to prior studies on broadband economic impact, digital use case impact research, and descriptive analyses of issues such as the impact on telecommuting or online learning.

However, the following was identified in terms of relevant research on this topic:

- A study of digitization as a mitigation factor of SARS-CoV.[23] This study was based on a multivariate regression model of a panel of 170 countries' data of a production function combined with broadband penetration and a dummy variable for SARS CoV impact. Results indicated that countries with the largest broadband infrastructure had the ability to offset, at least partially, the negative effects of the pandemic.
- An analysis of the relationship between the digitization of production index and GDP downward adjustment from COVID-19.[24] This analysis presented a correlation between the IMF GDP downward adjustments and an index of digitization of production. The correlations indicated that while digitization had no apparent impact on a country's ability to mitigate the recession in 2020, countries with higher digitization of their economy tended to be associated with a smaller downward GDP adjustment in 2021, as forecast by the IMF.
- Preliminary analysis (Katz et al., in process), based on ordinary least squares of a panel regressing GDP impact (including a 2021 IMF forecast), of the relationship between fixed broadband penetration, fixed capital, labour and per capita spending on health care, and the number of COVID deaths per 1 000 000. The results indicated that within the top connectivity countries, more than half of the long-term negative economic impact could be reduced by digital infrastructure.

2.2. Limits to the capacity of digital infrastructure to increase resilience in the face of pandemics

Having established, at least partially, the contribution of digital infrastructure to the mitigation of some of the pandemic effects, it was pertinent to understand if there were any potential limits to the positive contribution of digitization. All roundtable experts agreed that the primary limitation was the digital

[23] Katz, R., Jung, J. and Callorda, F. (2020). *Facing the COVID-19 pandemic: digitization and economic resilience in Latin America.* CAF Development Bank for Latin America, April.

[24] Katz, R., Jung, J. and Callorda, F. (2020). *Can digitization mitigate COVID-19 damages? Evidence from developing countries.* SSRN.

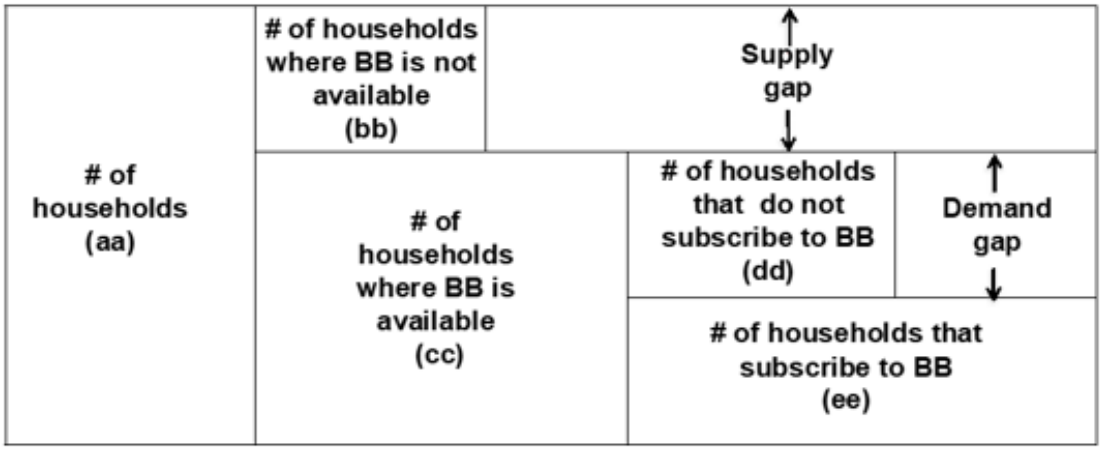
divide, with the consequent impact on the reduction in the capacity to telework, and for students to rely on distance learning. Research in both areas is quite conclusive in confirming this perspective. In addition, barriers could exist in other areas as well, such as the slow digitization of production and institutional failures in the implementation of upgrades to ICT capacity vis-à-vis the pandemic.

2.2.1. The impact of the digital divide

The digital divide within all nations and between advanced and developing economies has been further exposed by the pandemic. As stated by all roundtable experts, the gaps in reach and quality of digital connectivity as well as in Internet literacy would be a determining factor in the development of countries going forward. In the words of a roundtable expert "digitization is currently a mitigant of the pandemic-induced disruption for only a very small elite in Africa". Internet usage in the Africa region, though increasing is generally low: 50 per cent for South Africa was the highest, with Kenya and Nigeria around 30 per cent, and some countries around 10 per cent.[25] This view was similar to a perspective from an expert located in the Asia-Pacific region: "If you are not online, then you are missing out on everything - both normal livelihood and work. The government's responsive policies are also assuming the online economy works for everyone."

The debate about the digital divide in Internet use and broadband has largely revolved around the statistics on households that own a computer and have adopted broadband. Thus, political discussion and public opinion have been around the need to increase take-up by expanding telecommunication network coverage. The underlying premise is that the digital divide would be narrowed if the issues holding up infrastructure investment were resolved. Without denying that there is some causal relationship between investment and the divide, it is important to stress that one of the fundamental variables accounting for digital exclusion lies on the demand side rather than the supply side. While the supply gap measures the portion of the population of a given country that cannot access broadband because of lack of service, the demand gap focuses on the potential users that could buy broadband service (since operators offer it in their territory, either through fixed or wireless networks) but do not do so (see Figure 6).

Figure 6: Relationship between broadband supply and demand gap



Source: Katz and Berry (2014). Driving demand of broadband networks and services. London: Springer.

According to Figure 6, the supply gap is defined by the number of households where either fixed or mobile broadband are not available (bb), while the demand gap is measured by the non-subscribing households of those where broadband is available (dd). Accordingly, the concept of digital divide is the sum of both groups (bb + dd). While policy discussion has been intense regarding the need for

[25] Research ICT Africa (2018). *After Access survey*.

providing universal coverage (and therefore, eliminating the supply gap), the demand gap has not benefited from an equal level of attention. COVID-19 has brought this issue to the fore.

The constraints on the ability of digital infrastructure to enhance social and economic resilience have to do with both the supply (coverage) and demand (affordability and digital literacy) gaps. Research can already provide an indication of the supply and demand gaps as limits to the impact of digital infrastructure on fostering socio-economic resilience in the face of the pandemic. This highlights the importance of integrated supply and demand side measures in addressing this inequality. Although many countries have over 90 per cent broadband coverage (3G), they have less than 25 per cent Internet penetration. The barrier to Internet access also includes the cost of devices and service, digital illiteracy and lack of appropriate content.[26]

The digital divide as a limit to distance learning

National lockdowns and school closures have resulted in students being compelled to attend classes via broadband access from home. In this context, a critical question is the potential social impact of this move to home schooling supported by access to technology. As stated by one roundtable expert: "As a high percentage of the world's students are out of formal classes at the moment, the availability of remote learning for some students, but not others will create new digital divides which will impact the future career paths of students, particularly those in school-leaving years. The main cause of this new digital divide is a lack of affordable bandwidth, particularly outside major cities. But a secondary cause is a lack of suitable devices for remote learning, and a need to share them between several members of a family." The impact is likely to be long term with the loss of six months of education having a knock-on effect on future schooling, although the effects would be regional, with some rural areas, in particular, or poor parts of cities, suffering more than others. In Kenya, for instance, all students will be obliged to repeat the 2020 school year, irrespective of whether they have participated in online learning.

The impact of home broadband access on student performance was an area of research that had garnered considerable attention already before the pandemic.[27] Among the more robust analyses, the following conclusions were drawn:

- Having a computer at home increased school enrolment by 1.4 percentage points, after socio-demographic controls.[28]
- Teenagers who have access to home computers are 6 to 8 percentage points more likely to graduate from high school than teenagers who do not have access, when controlling for socio-demographics.[29]
- High school students with home computer access have a strong positive relationship with academic performance.[30]
- However, in a quasi-experimental approach, no evidence on educational outcomes such as grades and test scores were identified in a grade 6-10 group in California.[31]

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26 Katz, R. and Berry, T. (2014). *Driving demand of broadband networks and services*. London: Springer.

27 For survey of the research literature, see Bulman, G. and Fairlie, R. *Technology and Education: Computers, Software, and the Internet.* National Bureau of Economic Research Working Paper 22237, Cambridge, Massachusetts, 2016, retrieved from: http://www.nber.org/papers/w22237.

28 Fairlie, Robert W. 2005. "The Effects of Home Computers on School Enrollment," *Economics of Education Review* 24(5): 533-547.

29 Beltran, Daniel O., Kuntal K. Das, and Robert W. Fairlie. 2010. "Home Computers and Educational Outcomes: Evidence from the NLSY97 and CPS," *Economic Inquiry* 48(3): 771- 792.

30 Ibid.

31 Fairlie, Robert W., and Jonathan Robinson. 2013. "Experimental Evidence on the Effects of Home Computers on Academic Achievement among Schoolchildren," *American Economic Journal: Applied Economics* 5(3): 211-240.

- One important study in North Carolina found mild negative effects between home computer and broadband access and maths and reading test scores using panel data and fixed effects, although the broadband access variable was not clearly defined in this study.[32]
- Access to broadband among junior high school students increased their test scores, range of college applications and admissibility.[33]
- College graduation: Minority students are more likely to graduate from community college if they have access to a computer at home[34]

The critical fact in the research evidence presented above is that it was conducted under situations where classes were still delivered in schools. Under these conditions, home computer and broadband access represented a complement to the education received in class (the term used in the United States to quantify the students with no technology access was "homework gap"). Under lockdown conditions, the technology becomes the only link existing between the student and the teacher. In other words, the "homework gap" becomes the "school gap". One roundtable expert estimated that at least 1.5 billion students depend now on home schooling and distance learning. Along those lines, students with no computer and/or broadband access become forcibly excluded from attending school. In that regard, the statistics in an advanced economy such as the United States are quite alarming. The 2017 American Community Survey prepared by the U.S. Census Bureau estimates that 5 013 242 children under 18 years old reside in a household with a computer but no broadband subscription, while 2 036 753 children under 18 years old reside in a household without a computer. All in all, over 7 million students in the United States are affected by the "school gap" under pandemic-induced lockdown conditions. If this situation is that of an advanced economy with broadband adoption in excess of 85 per cent of households, it is fair to assume that the developing world is facing a much more serious situation.

The digital divide as a limit to telecommuting

When looking at the increase in Wi-Fi traffic and its impact on telecommunication networks, Chapter 2 noted the massive upsurge in telecommuting. Along these lines, it is also pertinent to examine impact of teleworking on the labour market and its social implications. What is the magnitude of the changes caused by the pandemic as measured by the number of workers who now work from home? Can we establish some perspective as to which sectors are most affected and which are least affected? In theory, knowledge workers (e.g., researchers and software developers) would adapt most easily to this new way of working. It is important to determine, then, the number of workers who – due to their occupations – cannot work from home. Four pieces of research have been issued since the outbreak of the pandemic and focus on estimating the portion of the labour force that could continue to work from home.

Relying on Chile's National Socio-economic Characterization Survey (CASEN) carried out by the Ministry of Social Development in 2017, Katz et al. (2020a)[35] assessed the likelihood of: a) occupations whose workers were likely to continue going to the workplace location (e.g. essential workers), and b) occupations that could not rely on telecommuting (for example, a factory operator cannot continue working if staying at home).[36] Once completed, the probability analysis yielded the percentage of the workforce that could work from home, the percentage that were obliged to continue to go to their workplace, and the percentage that could not telework. Of the 7 830 958 total employed workers

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32 Vigdor, Jacob L., Helen F. Ladd, and Erika Martinez. 2014. "Scaling the Digital Divide: Home Computer Technology and Student Achievement," *Economic Inquiry*. 52(3): 1103–1119.

33 Dettling, L., Goodman, S. and Smith, J. (2012). *Every little bit counts: the impact of high-speed internet on the transition to college.* Finance and Economics Discussion Series 2015-108. Washington: Board of Governors of the Federal Reserve System, retrieved from: http://dx.doi.org/10.17016/FEDS.2015.1.

34 This estimate is conservative since dropout rate is expected to be higher in rural counties than the national average.

35 Katz, R., Jung, J. and Callorda, F. (2020). *Facing the COVID-19 pandemic: digitization and economic resilience in Latin America.* CAF Development Bank for Latin America, April.

36 The probabilities for (a) were based on the official rules issued by governments for the so-called "essential" occupations, while the likelihood of (b) was based on the authors' understanding of work an occupation entails.

in Chile, 1 610 241 (20.6 per cent) were obliged to continue to go to their workplace (e.g., health personnel, security forces, food processing workers, etc.) because their occupations were considered to be essential. Based on lockdown rules, the remaining 6 220 717 workers (79.4 per cent) could not go to their workplace. Of these, 1 801 187 (28.9 per cent) could continue to work by telecommuting from home, while 4 419 530 (71.1 per cent) could not work remotely from home. In sum, under lockdown conditions of the 7 830 958 total workers in Chile, 56.4 per cent were either not allowed to go to work or could not continue to work by telecommuting.[37]

It is especially important to consider the social implications of these numbers. While some members of the workforce can continue to work under lockdown conditions, a large proportion of the total workforce face unemployment when the companies they work for cease operations, with each company choosing whether or not to continue paying its employees (as permitted by labour law). These social implications are even more serious when examining the number of affected workers with low education and/or low income. First, of the 1 801 187 workers who could telework, 1 234 063 (or 68.5 per cent) had higher education degrees and 1 322 528 (73.4 per cent) were in the 4th or 5th income quintiles. Second, of the 4 419 530 workers who could not go to the workplace and could not work remotely, 1 615 099 (36.5 per cent) had – at most – a basic level of education and 1 509 041 (or 34.1 per cent) fell within the 1st or 2nd income quintiles.

A similar analysis was conducted by Katz et al. (2020b)[38] for South Africa, relying on statistics from South Africa's Quarterly Labour Force Survey carried out by the Department of Statistics in the fourth quarter of 2019. In this case, of the 16 640 794 employed workers, under lockdown conditions, the remaining 13 503 278 workers (81.2 per cent) could not go to their workplace. Of these 13 503 278 workers, 3 500 786 (25.9 per cent) could continue to work by telecommuting from home. The remaining 10 002 492 workers (74.1 per cent) could not work remotely from home. In sum, of the 16 640 794 total workers in South Africa, 60.1 per cent were either not allowed to go to work or could not continue to work by telecommuting. The analysis by educational and inclusion levels within the formal sector indicates the disproportionate impact of disruption on the most vulnerable social groups. The percentage of people that remains employed was, as expected, much larger for highly educated people and for those workers associated with the formal sector. Of the 10 million workers (60 per cent of the workforce) that could not go to work or telecommute, 39 per cent were in the informal sector. In contrast, there were no big differences by gender in the percentage that stayed employed.

By applying the work-from-home classification from Occupational Information Network (O*NET) surveys to U.S. Bureau of Labor Statistics, Dingel et al., (2020) estimate that 37 per cent of jobs in the United States could rely on telecommuting. While the authors did not conduct an analysis by income or education, they estimated that over 45 per cent of jobs in San Francisco, San Jose, and Washington DC, three cities with a concentration of high-income population, could be done from home.[39]

Albrieu (2020) relies on Dingel et al. (2020) methodology and estimates that in the case of Argentina, according to an occupational analysis of the National Household Survey, between 27 per cent and 29 per cent of the labour force of 11.8 million could rely on telecommuting. However, an analysis of the effective use of ICT (availability of PCs and in-home broadband connectivity) among that base resulted in a reduction to 18 per cent. The social implications in this case were similar to the ones drawn for Chile and South Africa. Fifty per cent of jobs in the top income decile could be handled through teleworking, while that ratio drops to one in 10 in the lowest decile.[40]

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37 This percentage is consistent with the estimate of Hevia & Neumeyer (2020) who calculated the number of affected employees per company based on PIAAC data. The authors estimated that 53 per cent of the workforce in Latin America could risk unemployment because they work for companies with five or fewer employees and with limited access to emergency funding.

38 Katz, R., Jung, J. and Callorda, F. (2020). *Digitization: a resiliency plan for developing countries facing pandemics.* Presentation to the International Finance Corporation.

39 Dingel, J., Neiman, B. (2020). *How many jobs can be done at home?* Becker Friedman Institute for Economics at University of Chicago (April).

40 Albrieu, R. (2020). *Evaluando las oportunidades y los limites del teletrabajo en Argentina en tiempos del COVID-19*. Buenos Aires: CIPPEC (April).

Even after the COVID crisis passes, researchers do not expect a full return to the prior working and studying patterns. Flannery et al. (2020) estimate, once the pandemic subsides, we will end up with some hybrid version of today (54 per cent working full/part time from home) and where we were prior to the crisis (27 per cent). Many more may continue to work from home several days a week, thus still needing the telecommuting infrastructure even if they do return to the office on a semi-regular basis.[41]

The digital divide as a limit to social resilience

Beyond the impact on distance education and telecommuting, the digital divide will exacerbate the disadvantage of unserved or non-digitally literate populations, limiting their access to payments and commerce (for the unbanked) or healthcare services and information (for the elderly, among others).

2.2.2. Digitization of production

Are there any limitations to the power of digital infrastructure to support the production side of the economy? Are large corporations better prepared to continue operating while SMEs face greater disruptions? What are the sectors that are better prepared in terms of their digital transformation? What about the ability of digital infrastructure to increase supply chain resilience in the face of the pandemic?

Digital resilience by size of establishment

Different views were presented with regard to the type of enterprises which would most likely be disrupted by the pandemic, when considering their level of digitization. One group of experts argued that large corporations have well-established digital solutions in place (collaboration tools, employee devices, cloud services, VPN, etc.), while being more resilient and financially stronger. Furthermore, SMEs would be more affected because of their concentration in the retail and hospitality sector, which is being severely impacted by closures and restrictions due to social distancing, and so on.

Another group considered that SMEs have the ability to move online quickly and adapt to the new environment. For example, most SMEs are more agile in changing their business models and adapting their online sales/channels. A roundtable expert stated that there are some indications that the informal sector and SMEs have been able to pivot more quickly to respond to changing demands, while large online companies have continued to do things in the same way without dealing with context-specific disruptions.

In the end, most experts agreed that the answer to this question would depend upon the sector. For example, a large manufacturing firm would still struggle due to lockdown restrictions impacting the production line, while any SMEs in their supply chain would also be negatively impacted. On the other hand, firms already in the digital economy space would find it easier to cope. In this sector, large global digital economy players remained fairly agile and able to adapt to the COVID-19-induced conditions.

Digital resilience by sector

Roundtable experts concurred with the view that as businesses, public sector bodies and ICT providers looked to address the changed environment, many industries accelerated digitalization and automation. This is true even in areas that had previously lagged behind, e.g., the healthcare sector which had been slow to adopt Internet-of-Things (IoT) solutions. For example, connected medical devices (both clinical and consumer grade) and e-health are seeing increased demand, due to the need for remote consultation and diagnoses; while in logistics and supply chain, connected solutions and asset tracking have enabled fast rerouting of supply chains to help fill gaps (for key goods, medicines and equipment), and support business resilience. Additionally, telecommunication service providers have been actively repurposing IoT solutions including infrared cameras, home alarm systems, and autonomous delivery vehicles and drones, for monitoring, public health announcements, disinfectant

[41] Flannery, S., Park, L., Lam, L. Roper, A., and Barajas, D. (2020). *Mapping the new normal for telecom services & communications infrastructure*. Morgan Stanley (June 11).

spraying and deliveries to affected areas. In some cases, the shift to digital is driven "bottom-up" by consumers, e.g. the adoption of connected thermometers by a broad base of consumers in the United States meant that temperature data points were being uploaded and shared at scale across the country and could be used to predict virus hotspots in advance.

In other sectors where digitization had been ongoing for a while, the pandemic has highlighted its value (e.g. for logistics and supply chain, where much greater agility is enabled through the use of track-and-trace applications, connected and integrated fleet management; or for retailers, where there has been an increased uptake of contactless payment terminals and solutions). This may lead to increased investment in digital solutions. This does not encompass only telecommunications but also data management, automation, and in some cases, artificial intelligence.

On the other hand, low digitization sectors, such as construction, will be hard hit. As an example, a roundtable expert located in the Asia-Pacific region mentioned that the construction sector in Singapore would shrink by 10.3 per cent this year due to the COVID-19 impact.

Digital resilience and supply chains

As explained in Calatayud et al. (2019)[42], production in modern economies is organized around supply chains, which involve business processes ranging from product design to customer delivery.[43] The performance of supply chains is driven by the efforts and behaviours of multiple stakeholders, such as manufacturers, logistics service providers and technology suppliers, and enabled by public policies on developing a country's infrastructure and business environment.[44] The increasing interdependency of supply chain stakeholders is the result of a number of business trends that have emerged in the last three decades, including process and product specialization, outsourcing, offshoring, just-in-time production and consumer-driven production. With design, production and distribution processes scattered among a variety of firms and parties, companies no longer compete in isolation, but rather as participants in interconnected supply chains.

According to one roundtable expert, supply chains in advanced economies have actually adjusted remarkably quickly to the challenges of COVID-19. Digitization has certainly helped on this front – specifically, simple connected solutions like asset tracking (e.g. for shipments and logistics) combined with monitoring dashboards and fleet management solutions were able to deliver a lot of agility to the supply chain and that has been fully demonstrated by how quickly supply chains had been reconfigured to adjust. Cellular coverage and availability represent key underlying features.

A second perspective was less optimistic about the ability of supply chains to face the disruption. Firstly, as explained by one roundtable expert, the digitization of supply chains without the digital transformation of analogue complements (customs, ports, etc.) would fail. Another expert added that supply chains were not shielded from disruption risk embodied by the stress of a COVID-like disruption. Digital infrastructures have to be stress-tested to respond of various shock scenarios to determine the actions that should be taken to rebuild their supply chains and mitigate future risks. A comprehensive understanding of supply-chain risk should consider two distinct elements: 1) the underlying vulnerabilities in the supply chain that make it fragile; 2) the level of exposure or susceptibility to unforeseen events (or shocks) that exploit these vulnerabilities. Investing in resiliency and continuity could help companies manage the risk or loss from future crises and disruptions.[45]

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42 Calatayud, A., Lechmacher, W., Betti, F. and Katz, R. (2019). *Supply Chain 4.0 Global Practices and Lessons Learned for Latin America and the Caribbean*. World Economic Forum.

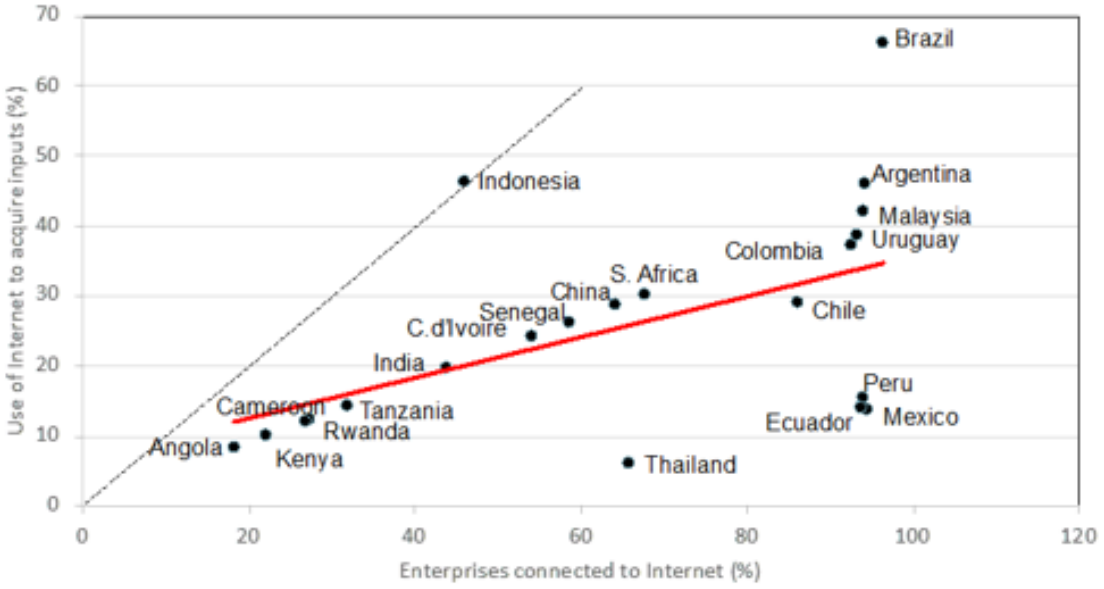
43 The concept of supply chain is different from value chain. A value chain is used either as a set of interrelated activities a company relies upon to create value and build competitive advantage (see Porter, M., *Competitive Strategy*, New York: Simon and Shuster, 1995) or a combination of different industry players to meet a market requirement (see Stigler, G., "The Division of Labor is Limited by the Extent of the Market", *The Journal of Political Economy*, vol. 59, no. 3, 1951, pp. 185-193).

44 Calatayud, A., *The connected supply chain: Enhancing risk management in a changing world*, Inter-American Development Bank Discussion Paper No. IDB-DP-508, 2017.

45 McKinsey & Co. *Is your supply chain risk blind or risk resilient?*

The above perspectives differ dramatically from the situation in developing countries. As explained by another roundtable expert, in Africa for example, lockdowns have resulted in the rupture of informal value chains, which has led to a major urban food security crisis in some areas. The potential destruction of these survivalist economies has meant that the informal economy has often been unable to serve as the usual buffer to economic shocks. The low enterprise adoption of the Internet indicates a very limited digital substitution of informal physical business activities such as the procurement of supplies or distribution of products and services.[46] The use of the Internet for business purposes in sub-Sahara Africa is as low as 7 per cent on average. South Africa has the highest Internet use by informal enterprises (24 per cent), followed by Senegal (20 per cent). Internet use by informal enterprises in Ghana and Mozambique is slightly higher than the overall average, at 8 per cent and 7 per cent respectively, but in Kenya (4 per cent) and Uganda (4 per cent) it is far lower. Rwanda, one of the poorest countries among the surveyed countries, has the lowest Internet use among informal entrepreneurs, with only 1 per cent of them using the Internet. Figure 7 provides evidence which suggests that while Internet adoption at the enterprise level in developing countries is high, the use of the Internet in supply chain operations is low.

Figure 7: Percent of enterprises connected to the Internet vs percent of enterprises using the Internet to acquire inputs (2018)



Note: The difference between countries is mainly due to differences in survey sampling approaches (e.g. inclusion or not of microenterprises).

Sources: Statistics offices and Ministries of the respective countries; Katz, R., Jung, J. and Callorda, F. (2020). Can digitization mitigate COVID-19 damages? Evidence from developing countries. SSRN.

From the sample of countries presented in Figure 7, only Indonesia seems to have a level of use of the Internet in the supply chain comparable with its level of Internet adoption among enterprises.

Another example of bottlenecks in the supply chain is related to governments' limited capacity to support foreign trade. Despite the progress in many nations that has occurred in recent years, developing countries continue to lag behind international best practices. Evidence of this lag, for example, can be seen in the time required to process foreign trade documentation by customs agencies (see Table 3).

[46] Research ICT Africa (2020). A *demand side view of informality and financial inclusion* (February 27).

Table 3: Time required to process foreign trade documentation (2018, in hours)

Region	Exports	Imports
Asia-Pacific	55.6	53.7
Latin America & Caribbean	35.7	43.2
MENA	66.4	72.5
South Asia	73.7	93.7
Africa	71.9	96.1
OECD	2.3	3.4

Source: World Bank. Doing Business 2019.

Therefore, the limited digitization of companies – mainly of SMEs – along with logistics chain bottlenecks represent obstacles to the development of supply chain resilience to deal with COVID-19.

2.2.3. The impact of institutional failures

To begin with, experts were very clear about the multiple initiatives of policy-makers and regulators to help improve the performance of digital infrastructure in mitigating the impact of the pandemic. For example, OMDIA has counted over 250 regulatory responses to the virus worldwide, impacting the telecommunication and ICT sector.[47] These fall into several categories including mandating the lifting of broadband speed caps, making additional spectrum available immediately (e.g. in the United States, the FCC has granted temporary spectrum access to 33 mobile Internet service providers to help them ensure connectivity in rural communities during the COVID-19 pandemic. For instance, the Special Temporary Authority (STA) allowed companies to use the lower 45MHz of spectrum in the 5.9GHz band for 60 days); postponement of operators' fees and taxes; and suspension of net neutrality regulations.

However, the response to the pandemic challenge has highlighted some critical policy shortfalls, which have characterized the way the digital sector has functioned until now. In particular, the failure to enable critical infrastructure deployment (wholesale access, i.e. connectivity to backbones such as submarine cables and terrestrial long-haul networks) and the expected persistence of governments to extract rents based on spectrum auctions, will keep input prices high, with a negative impact on digital affordability. To perpetuate this situation, governments could perceive spectrum auctions as an opportunity to offset massively the debt incurred from COVID-19, rather than as an opportunity for reinvestment to redress digital inequality.

[47] OMDIA (2020). *Telecoms regulation COVID-19 Tracker*.

3. Industry implications

In the light of the assessment provided above, roundtable experts were asked about potential recommendations to policy-makers and regulators in order to increase the power of digital infrastructure to mitigate the pandemic disruption. In response, a roundtable expert was fairly adamant about the need to re-examine some of the digital sector basic fundamental premises that were held before COVID-19. "If there is one important realization from COVID-19 it must be we cannot go back to the ways things were: we cannot go back to the extremely different experiences we had before the pandemic. Digital inequality has been a critical determinant of survival and life opportunities under lockdown. From a policy and regulatory perspective, we cannot do the same things again and hope for different outcomes – we need to embark on policy experimentation in developing countries that are going to be more financially constrained than ever; these policies should be aimed at more equitable and affordable broadband access. This will require reviewing everything we have taken as givens, from the way and what we license spectrum, to the way we govern and fund global public goods such as the Internet." As another roundtable expert stated: "At the theoretical level, digital technologies could make an enormous difference but in the practical world, we need to know whether the policy-makers see it that way or how they respond to challenges."

3.1. The role of governments

For the first time, in many emerging markets, digital infrastructure is seen as "essential", along with traditional infrastructure sectors, or even more so. As one roundtable expert stated: "Connectivity is the national critical infrastructure that is now as important as water, electricity and food to a nation. After clinical treatments, connectivity will be the single most important industry that will drive business and society out of lockdown".

Unfortunately, the pandemic has also exposed the access and connectivity limitations that digital infrastructure faces in less developed markets. These limitations are both technology based and not (the latter to include literacy, affordability and lack of relevant local content). This is the time that the cost of the digital divide has become more obvious than ever and this is the time that governments should see it as an opportunity to digitalize their economies.

The pandemic has demonstrated the importance of digital connectivity for people and economies in emerging markets. It is therefore crucial for governments to learn from these hard lessons and take concrete, actionable measures in the telecommunication sector to enable the private sector to provide universal access to quality digital infrastructure networks for all and support the development of a digital economy. For example, in the short term, governments and operators could focus on immediate sector needs including the release of emergency spectrum, deferring licence fee payments, or issuing technology-neutral licences.

3.1.1. The need for a digital resilience plan

Governments should take a much broader, holistic view of investment in high-speed broadband networks, considering the economic, social and environmental/climate benefits and costs of investment. The COVID-19 experience will, over time, provide valuable data on the cost of not having a fully-formed mitigation plan in place.

The different components of broadband networks (backbones, access, IXP, etc.) tend to operate independently. This raises the need, as proposed by a roundtable expert, to provide for better coordination between different networks and their owners/operators in the event of network failures (e.g. better fail-over mechanisms, operator-led rather than end-user-led networks). Similarly, there may be a need for a more coordinated approach to monitoring quality of service for all user groups, at a high level of "resolution", framed around improving reliability and resilience under a "high-load" case (e.g. where more people need to work from home, for a longer period of time). As one roundtable

expert stated: “We may need to think about network quality and resilience differently in the future than how we do today.”

Looking to the future, it is critical that countries begin work immediately on a digital resilience plan to address future pandemic disruptions. This will require, in the first place, a comprehensive diagnosis to be conducted of country resilience covering areas such as infrastructure deployment, service quality, stress testing of current infrastructure deployed, the components of digital divide (urban vs rural, income groups, large enterprises vs SMEs), an assessment of applications and usage levels across social groups, the evaluation of the level of digitization of production (by sector and enterprise size, entailing both technology adoption and assimilation in business processes) and the resilience of State operations (administrative processes and delivery of public services). After that, countries will be able to develop plans to address their respective shortfalls and to be better prepared for the next pandemic. The plans should address infrastructure deployment (backbone and distribution networks, spectrum availability, both licensed and unlicensed), initiatives to address all components of the digital divide, training and stimulation of consumer apps, concurrent efforts with the private sector to stimulate the digital transformation of production, as well as initiatives to address shortfalls in State operations.

Building digital resilience demands capable and adaptive institutions to manage the increasing complexity of globally integrated infrastructures and markets and coordinate across the public sector and between public and private sectors, enabling experimentation to deliver on public policy objectives.

3.1.2. A new regulatory framework?

Regulatory frameworks may need to be adjusted to stimulate investment whilst maintaining a “sensible” level of competition shifting from a “purist” to a “pragmatic” viewpoint on State aid regulations. This should prompt governments and regulators, in the words of a roundtable expert, “to double down on the release of spectrum, planning authorization and competition regulation”.

Several policy initiatives around spectrum policy for consideration were pointed out by roundtable experts. In developing countries, the opportunity of implementing spectrum licensing conditioned upon infrastructure sharing, enabling secondary and dynamic spectrum use, implementing default licensing exemption for communities, and making 5G licences conditional on meeting substantive coverage of earlier technologies (4G) should be considered. In all countries, advanced and developing, expanding the amount of spectrum allowed for unlicensed use should also be considered.

3.1.3. The importance of infrastructure sharing

It is paramount for governments in emerging markets to keep making progress on digital infrastructure regulation, particularly pertaining to shared infrastructure. In the aftermath of the COVID-19 situation, increased interest from governments, development finance institutions and non-traditional ICT infrastructure investors, will most likely drive the emergence of shared ICT infrastructure models to encourage capital intensive deep fibre investments that are critical for 4G and 5G deployment. This will increase economic resilience across multiple sectors and ultimately enable last-mile fibre access that facilitates better densification, broadband competition and the narrowing of the digital divide.

3.1.4. Digital divide priority

As stated by a roundtable participant: “Governments must take action and develop investment cases to support ubiquitous access to high-speed broadband, taking into account all the economic, social and environmental impacts”. Priorities for investments are in bankable rural business models as well as broadband connectivity predominantly in the area of shared, carrier-neutral infrastructure that could reduce the break-even cost of deploying costly infrastructure in sparsely populated, poor regions. Shared infrastructure has been proven to be a model in tower and submarine cable infrastructure, and it is time to apply it to terrestrial broadband infrastructure as well.

3.2. A need to re-examine capital investment of telecommunication operators

In all fairness, roundtable experts did not all agree on the need to rethink future capital spending trends. One perspective was captured in the words of one expert: "Connectivity is one of the solutions to COVID-19. Both mobile and fibre are as important to a nation's development in the next five years as any other utility." This should prompt a faster roll-out of high-speed broadband underpinned by a very strong investment case.

A divergent view argued for a "diversion of productive private capital investments from 5G to other broadband networks" or incentivizing new non-traditional investors in "new" technologies (dynamic spectrum). Along those lines, prompted by government policy, carriers should revive rural connectivity agendas, which had become low priority in order to favour 5G deployment.

3.3. An acceleration of the digitization of production

The roundtable experts estimated that COVID-19 could be a window of opportunity to drive digital transformation in sectors in which it had not been a focus in recent decades. Similar to the effect of SARS in China in 2003 which triggered tremendous growth in e-commerce, new production modes would emerge. As a result, COVID could become a catalyst for the adoption of digitalization in sectors where it had not occurred before, especially in more business-oriented applications.

In order to increase the digital resilience of production, enterprises engaged in the manufacturing of physical goods should accelerate their migration to automated processes to enable the production of physical goods with less manpower (environments characterized by the "remote control" of production). In the words of one expert, this approach should focus on "re-examining production chains, emphasizing the role of critical national infrastructure as an enabler, the multiplicity/diversity of supply, assurance and quality of service, the role of trusted suppliers, and better fail-over mechanisms".

As stated by another roundtable expert: "There's a popular meme that neatly captures the tipping point of digital: it is a short questionnaire asking who is driving your digital transformation. The first two options are "CEO" and "chief digital officer." Below that, highlighted with a bright red circle, is "COVID-19."

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